

Claims

- [c1] 1. A multiphase compressing air assembly for supplying compressed air to a system, said assembly comprising:
a first compressor drivingly connectable to a power source and operable to compress air for the system,
said first compressor including a first inlet, a spaced first outlet, and a first impeller fluidly between the first inlet and first outlet to compress air;
a second compressor drivingly connectable to the power source and operable to compress air for the system,
said second compressor including a second inlet, a spaced second outlet, and a second impeller fluidly between the second inlet and second outlet to compress air; and
a fluid flow control assembly fluidly intercommunicating the compressors so that the compressors cooperatively provide compressed air to the system in a number of operating phases, including a first phase in which at least some compressed air from the first outlet is supplied to the second inlet and a second phase in which at least some compressed air from the first and second outlets is supplied to the system without passing through the other compressor.
- [c2] 2. The assembly as claimed in claim 1; and
a drive assembly operable to drivingly connect the compressors to the power source so that each of the compressors operates continuously with operation of the power source.
- [c3] 3. The assembly as claimed in claim 2,
said first and second impellers being rotatable, each being operable to compress air for the system when rotated,

said first and second compressors including a transmission drivingly connecting the impellers to the drive assembly,
said transmission cooperating with the drive assembly to maintain rotation of the impellers at a substantially constant ratio relative to operation of the power source.

[c4] 4. The assembly as claimed in claim 3,
said transmission including a plurality of intermeshing gears with at least one of said gears being common to both compressors.

[c5] 5. The assembly as claimed in claim 4,
said transmission including a common rotatable transmission shaft coupled to said common gear,
said drive assembly including an endless element entraining at least a portion of said common shaft and being operable to entrain at least a portion of the power source.

[c6] 6. The assembly as claimed in claim 1,
said fluid flow control assembly fluidly intercommunicating the compressors so that in all operating phases both compressors compress at least some air for the system whenever the power source is operating.

[c7] 7. The assembly as claimed in claim 6,
said fluid flow control assembly being operable to fluidly intercommunicate the compressors with the system so that in all operating phases substantially all of the air compressed by each of the compressors is delivered to the system.

[c8] 8. The assembly as claimed in claim 1,
said first phase including a series phase in which substantially all compressed air from the first outlet is supplied to the second inlet.

- [c9] 9. The assembly as claimed in claim 8,
said second phase including a parallel phase in which substantially all
compressed air from the first and second outlets is supplied directly to the
system.
- [c10] 10. The assembly as claimed in claim 9,
said fluid flow control assembly being configured to switch operation of
the compressors from the series phase to the parallel phase in response
to a predetermined condition.
- [c11] 11. The assembly as claimed in claim 10,
said predetermined condition being an increase in pressure in the system
downstream of the first and second compressors.
- [c12] 12. The assembly as claimed in claim 11,
said fluid flow control assembly being configured to switch operation of
the compressors from the parallel phase to the series phase in response
to a second predetermined condition.
- [c13] 13. The assembly as claimed in claim 12,
said predetermined condition being a decrease in pressure in the system
downstream of the first and second compressors.
- [c14] 14. The assembly as claimed in claim 1; and
a case presenting a compression chamber and a transmission chamber,
said first and second compressors being at least partially housed within
said compression chamber.
- [c15] 15. The assembly as claimed in claim 1,
said fluid flow control assembly including a passageway fluidly
communicating said first outlet and said second inlet,

said fluid flow control assembly further including a first valve disposed along said passageway for controlling the flow of compressed air there through.

[c16] 16. The assembly as claimed in claim 15,
said first valve shiftable between an open position wherein compressed air can flow through said passageway and a closed position wherein compressed air is prevented from flowing through said passageway.

[c17] 17. The assembly as claimed in claim 15,
said fluid flow control assembly including an additional passageway in fluid communication with said first outlet and operable to be in fluid communication with the system,
said fluid flow control assembly further including a second valve disposed along said additional passageway downstream of said first-mentioned passageway for controlling the flow of compressed air through said additional passageway.

[c18] 18. The assembly as claimed in claim 17,
said second valve shiftable between an open position wherein compressed air can flow through said additional passageway and a closed position wherein compressed air is prevented from flowing through said additional passageway.

[c19] 19. The assembly as claimed in claim 17,
said fluid flow control assembly including a second additional passageway in fluid communication with said second inlet,
said fluid flow control assembly further including a third valve disposed along said second additional passageway upstream of said first-mentioned passageway for controlling the flow of air through said second

additional passageway.

- [c20] 20. The assembly as claimed in claim 19, said third valve shiftable between an open position wherein air can flow through said second additional passageway and a closed position wherein air is prevented from flowing through said second additional passageway.
- [c21] 21. The assembly as claimed in claim 19; and a case presenting a compression chamber and a transmission chamber, said first and second compressors and said fluid flow control assembly being at least partially housed within said compression chamber, said compression chamber presenting a case inlet in fluid communication with the atmosphere.
- [c22] 22. The assembly as claimed in claim 21, said fluid flow control assembly including a third additional passageway fluidly communicating the case inlet with said first inlet and fluidly communicating the case inlet with said second additional passageway, said fluid flow control assembly further including a fourth valve disposed along said third additional passageway for controlling the flow of air there through.
- [c23] 23. The assembly as claimed in claim 22, said fourth valve shiftable between an open position wherein air can flow through said third additional passageway and a partially closed position wherein at least some air is prevented from flowing through said third additional passageway.
- [c24] 24. A method of supplying compressed air to a system, said method comprising the steps of:

- (a) driving a first compressor off of a power source to compress air;
- (b) driving a second compressor off of the power source to compress air;
- (c) operating the compressors at least partially in series so that at least some air that is compressed by the first compressor is further compressed by the second compressor and then supplied to the system; and
- (d) operating the compressors at least partially in parallel so that at least a portion of air is compressed by the first compressor and at least another portion of air is compressed by the second compressor and the at least a portion and at least another portion of compressed air are supplied to the system without passing through the other compressor.

[c25] 25. The method as claimed in claim 24,
step (d) being performed after step (c) so that operation of the compressors phases from at least partially in series to at least partially in parallel in response to a predetermined condition,
said predetermined condition comprising an increase in pressure in the system downstream of the first and second compressors.

[c26] 26. The method as claimed in claim 24,
step (d) including the step of switching operation of the compressors to substantially fully parallel in response to a predetermined condition so that at least a portion of air is compressed by the first compressors and at least another portion of air is compressed by the second compressor and the at least a portion and at least another portion of compressed air are supplied to the system without passing through the other compressor wherein said at least a portion and said at least another portion of compressed air comprise substantially all compressed air supplied to the system.

- [c27] 27. The method as claimed in claim 26,
said predetermined condition an increase in pressure in the system
downstream of the first and second compressors.
- [c28] 28. The method as claimed in claim 24,
steps (a) and (b) each including the step of drivingly connecting the
compressors to the power source so that each of the compressors
operates continuously with operation of the power source.
- [c29] 29. The method as claimed in claim 28,
steps (a) and (b) each further including the step of drivingly connecting
the compressors to the power source so that each of the compressors
operates at a substantially constant ratio relative to the operation of the
power source.
- [c30] 30. The method as claimed in claim 28,
steps (a) and (b) including the common step of intermeshing a common
gear between the compressors.
- [c31] 31. The method as claimed in claim 30,
steps (a) and (b) further including the common steps of entraining an
endless element around at least a portion of the power source and driving
the common gear at least in part with the endless element.
- [c32] 32. The method as claimed in claim 24,
steps (c) and (d) each including the step of operating both compressors
so that each compressor compresses at least some air that is supplied to
the system whenever the power source is operating.
- [c33] 33. The method as claimed in claim 32,
steps (c) and (d) each further including the step of delivering substantially

all of the air compressed by the compressors to the system.

[c34] 34. The method as claimed in claim 24,
step (c) including the step of operating the compressors substantially fully
in series so that substantially all air that is compressed by the first
compressor is further compressed by the second compressor and then
supplied to the system.

[c35] 35. The method as claimed in claim 24; and
(e) housing both compressors substantially within a case.

[c36] 36. The method as claimed in claim 24; and
(e) intercommunicating the first and second compressors and the
system,
step (e) including the steps of fluidly communicating the first and second
compressors with a serial passageway and disposing a first valve along
the serial passageway for controlling the flow of compressed air there
through.

[c37] 37. The method as claimed in claim 36,
step (c) including the step of shifting the first valve into an open position
wherein compressed air can flow through said serial passageway.

[c38] 38. The method as claimed in claim 36,
step (d) including the step of shifting the first valve into a closed position
wherein compressed air is prevented from flowing through said serial
passageway.

[c39] 39. The method as claimed in claim 36,
step (e) including the steps of fluidly communicating the first compressor
and the system with an additional passageway and disposing a second

- valve along the additional passageway for controlling the flow of compressed air there through.

- [c40] 40. The method as claimed in claim 39,
step (c) including the step of shifting the second valve into a closed position wherein compressed air is prevented from flowing through said additional passageway.
- [c41] 41. The method as claimed in claim 39,
step (d) including the step of shifting the second valve into an open position wherein compressed air can flow through said additional passageway.
- [c42] 42. The method as claimed in claim 39,
step (e) including the steps of fluidly communicating the second compressor and the atmosphere with a parallel passageway and disposing a third valve along the parallel passageway for controlling the flow of air there through.
- [c43] 43. The method as claimed in claim 42,
step (c) including the step of shifting the third valve into a closed position wherein air is prevented from flowing through said parallel passageway.
- [c44] 44. The method as claimed in claim 43,
step (d) including the step of shifting the third valve into an open position wherein air can flow through the parallel passageway.
- [c45] 45. The method as claimed in claim 42,
step (e) including the step of fluidly communicating the atmosphere, the first compressor, and the parallel passageway with an inlet passageway and disposing a fourth valve along said inlet passageway for controlling

the flow of air there through.

[c46] 46. The method as claimed in claim 45; and
(f) shifting the fourth valve into a partially closed position wherein at least some air is prevented from flowing through said inlet passageway.

[c47] 47. In a pneumatic conveyor including tubing and a power source, an improved centrifugal air compressing system comprising:
a first compressor drivingly connected to the power source for compressing air for the tubing,
said first compressor including a first inlet, a spaced first outlet, and a first impeller fluidly between the first inlet and first outlet to compress air;
a second compressor drivingly connected to the power source for compressing air for the tubing,
said second compressor including a second inlet, a spaced second outlet, and a second impeller fluidly between the second inlet and second outlet to compress air; and
a fluid flow control assembly fluidly intercommunicating the compressors so that the compressors cooperatively provide compressed air to the tubing in a number of operating phases, including a first phase in which at least some compressed air from the first outlet is supplied to the second inlet and a second phase in which at least some compressed air from the first and second outlets is supplied to the tubing without passing through the other compressor.

[c48] 48. In a pneumatic conveyor as claimed in claim 47; and
a drive assembly drivingly connecting the compressors to the power source so that each of the compressors operates continuously with operation of the power source.

- [c49] 49. In a pneumatic conveyor as claimed in claim 48,
said first and second impellers being rotatable to compress air for the
tubing when rotated,
said first and second compressors including a transmission drivingly
connecting the impellers to the drive assembly,
said transmission cooperating with the drive assembly to maintain
rotation of the impellers at a substantially constant ratio relative to the
operation of the power source.
- [c50] 50. In a pneumatic conveyor as claimed in claim 49,
said transmission including a plurality of intermeshing gears with at least
one of said gears being common to both compressors.
- [c51] 51. In a pneumatic conveyor as claimed in claim 50,
said transmission including a common rotatable transmission shaft
coupled to said common gear,
said drive assembly including an endless element entraining at least a
portion of said common shaft and at least a portion of the power source.
- [c52] 52. In a pneumatic conveyor as claimed in claim 47,
said fluid flow control assembly fluidly intercommunicating the
compressors so that in all operating phases both compressors compress
at least some air for the tubing whenever the power source is operating.
- [c53] 53. In a pneumatic conveyor as claimed in claim 52,
said fluid flow control assembly being operable to fluidly
intercommunicate the compressors with the tubing so that in all operating
phases substantially all of the air compressed by each of the
compressors is delivered to the tubing.
- [c54] 54. In a pneumatic conveyor as claimed in claim 47,

said first phase including a series phase in which substantially all compressed air from the first outlet is supplied to the second inlet.

[c55] 55. In a pneumatic conveyor as claimed in claim 54,
said second phase including a parallel phase in which substantially all compressed air from the first and second outlets is supplied directly to the tubing.

[c56] 56. In a pneumatic conveyor as claimed in claim 55,
said fluid flow control assembly being configured to switch operation of the compressors from the series phase to the parallel phase in response to a predetermined condition.

[c57] 57. In a pneumatic conveyor as claimed in claim 56,
said predetermined condition being an increase in pressure in the tubing downstream of the first and second compressors.

[c58] 58. In a pneumatic conveyor as claimed in claim 57,
said fluid flow control assembly being configured to switch operation of the compressors from the parallel phase to the series phase in response to a second predetermined condition.

[c59] 59. In a pneumatic conveyor as claimed in claim 58,
said predetermined condition being a decrease in pressure in the tubing downstream of the first and second compressors.

[c60] 60. In a pneumatic conveyor as claimed in claim 47; and
a case presenting a compression chamber and a transmission chamber,
said first and second compressors being at least partially housed within said compression chamber.

[c61] 61. In a pneumatic conveyor as claimed in claim 47,

said fluid flow control assembly including a passageway fluidly communicating said first outlet and said second inlet, said fluid flow control assembly further including a first valve disposed along said passageway for controlling the flow of compressed air there through.

[c62] 62. In a pneumatic conveyor as claimed in claim 61, said first valve shiftable between an open position wherein compressed air can flow through said passageway and a closed position wherein compressed air is prevented from flowing through said passageway.

[c63] 63. In a pneumatic conveyor as claimed in claim 61, said fluid flow control assembly including an additional passageway in fluid communication with said first outlet and the tubing, said fluid flow control assembly further including a second valve disposed along said additional passageway downstream of said first-mentioned passageway for controlling the flow of compressed air through said additional passageway.

[c64] 64. In a pneumatic conveyor as claimed in claim 63, said second valve shiftable between an open position wherein compressed air can flow through said additional passageway and a closed position wherein compressed air is prevented from flowing through said additional passageway.

[c65] 65. In a pneumatic conveyor as claimed in claim 63, said fluid flow control assembly including a second additional passageway in fluid communication with said second inlet, said fluid flow control assembly further including a third valve disposed along said second additional passageway upstream of said first-

mentioned passageway for controlling the flow of air through said second additional passageway.

- [c66] 66. In a pneumatic conveyor as claimed in claim 65, said third valve shiftable between an open position wherein air can flow through said second additional passageway and a closed position wherein air is prevented from flowing through said second additional passageway.
- [c67] 67. In a pneumatic conveyor as claimed in claim 65; and a case presenting a compression chamber and a transmission chamber, said first and second compressors and said fluid flow control assembly being at least partially housed within said compression chamber, said compression chamber presenting a case inlet in fluid communication with the atmosphere.
- [c68] 68. In a pneumatic conveyor as claimed in claim 67, said fluid flow control assembly including a third additional passageway fluidly communicating the case inlet with said first inlet and fluidly communicating the case inlet with said second additional passageway, said fluid flow control assembly further including a fourth valve disposed along said third additional passageway for controlling the flow of air there through.
- [c69] 69. In a pneumatic conveyor as claimed in claim 68, said fourth valve shiftable between an open position wherein air can flow through said third additional passageway and a partially closed position wherein at least some air is prevented from flowing through said third additional passageway.